Status of SNS (and its Control System)

EPICS Collaboration Meeting

June 12 - 16, 2006

Dave Gurd

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

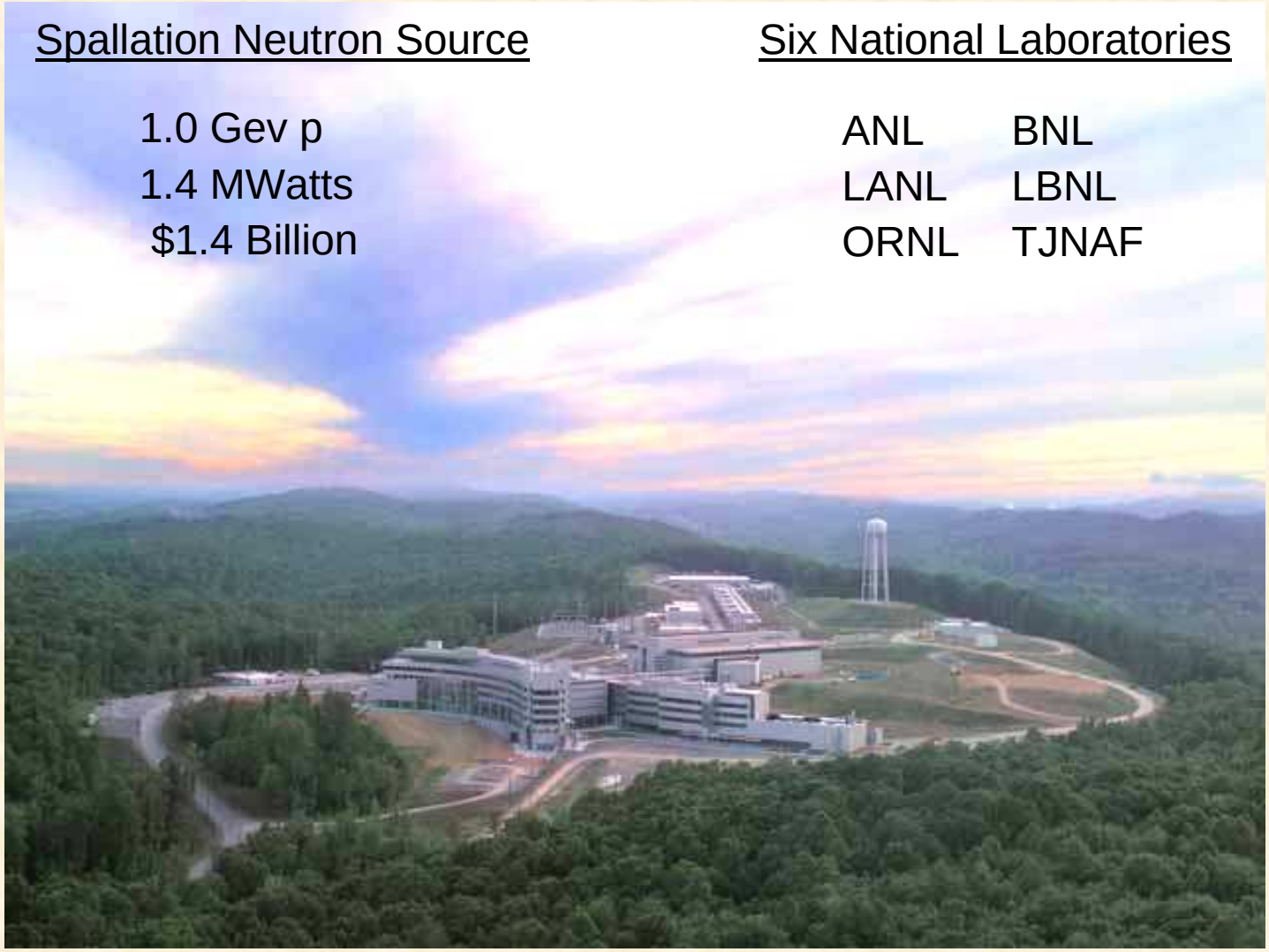
Real photo – (artist's conception of sky?)

Spallation Neutron Source

1.0 Gev p
1.4 MWatts
$1.4 Billion

Six National Laboratories

ANL BNL
LANL LBNL
ORNL TJNAF



Central Lab and Office Building

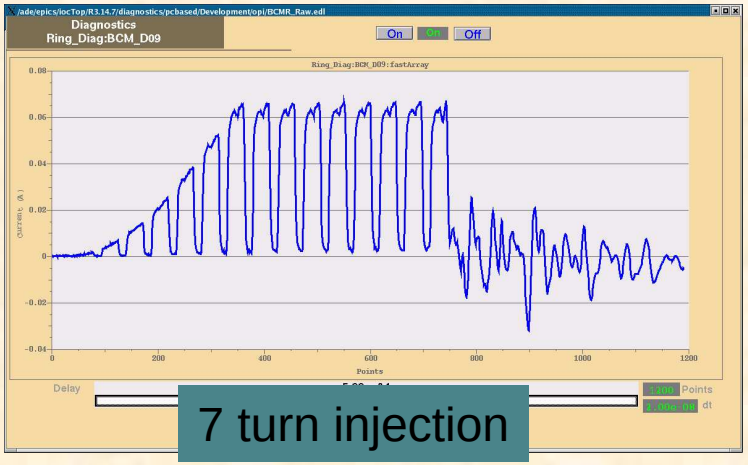
March 2005 – The Control Room is ready: "Bring it on…"

11 Consoles
60 Screens
+ PPS Console

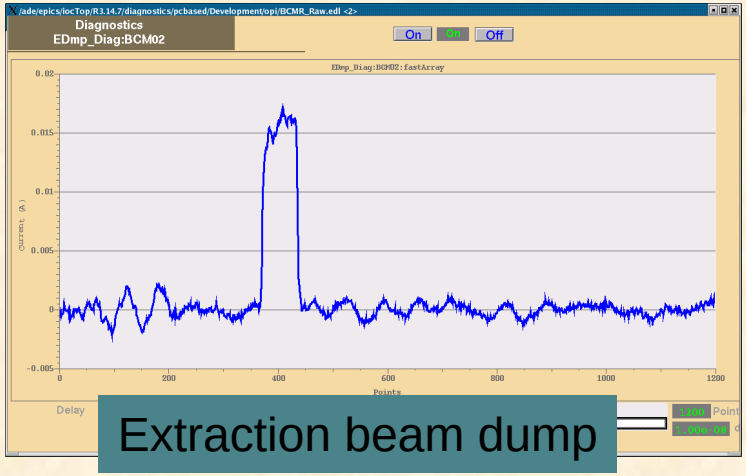
September '05 – The SCL is commissioned

- Built by JLab
- The first ever superconducting pulsed proton linac – considered risky at first.
- Reached 920 MeV at 4K – designed for 2K

January 14, 2006 – The Ring works!!



7 turn injection



Extraction beam dump

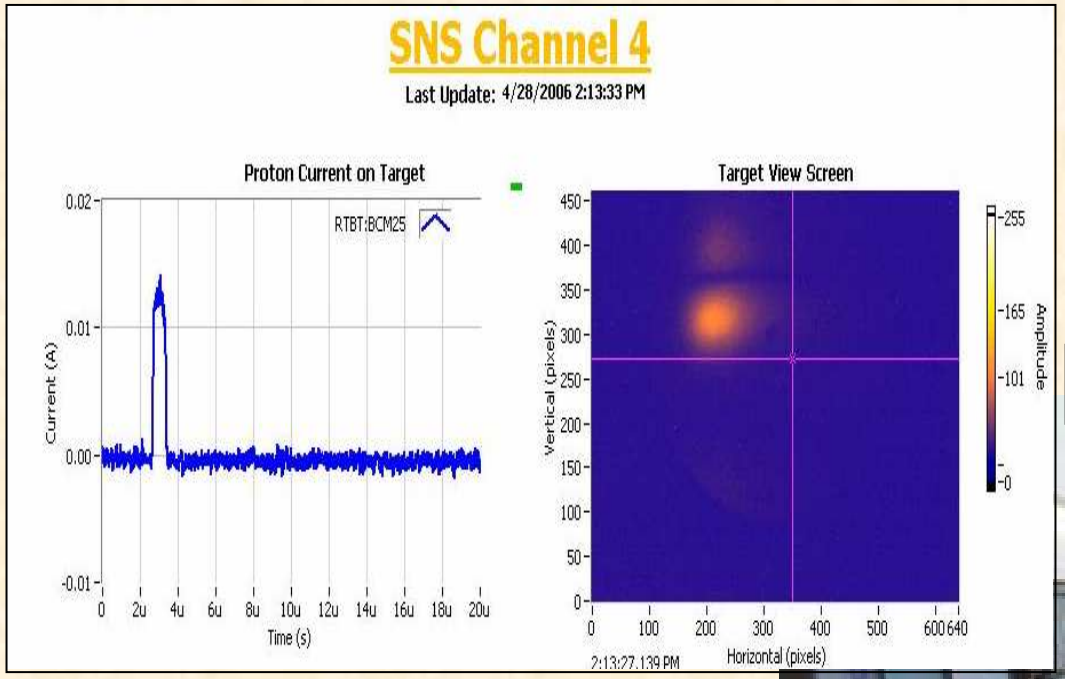
- **SCL was commissioned in September 2005**
- **From "turning the bend" to extracted beam in a weekend! First pulse was on stripper foil.**
- **Achieved CD4 intensity extracted on Jan 26.**
- **Went up to 5.0E13 bunched, 1.0E14 coasting per pulse. That's ~ ½ design bunched intensity per pulse.**
- **Completed Ring commissioning run one week earlier than planned.**

First Attempt at Beam on Target April 28, 2006

Cameras were rolling…

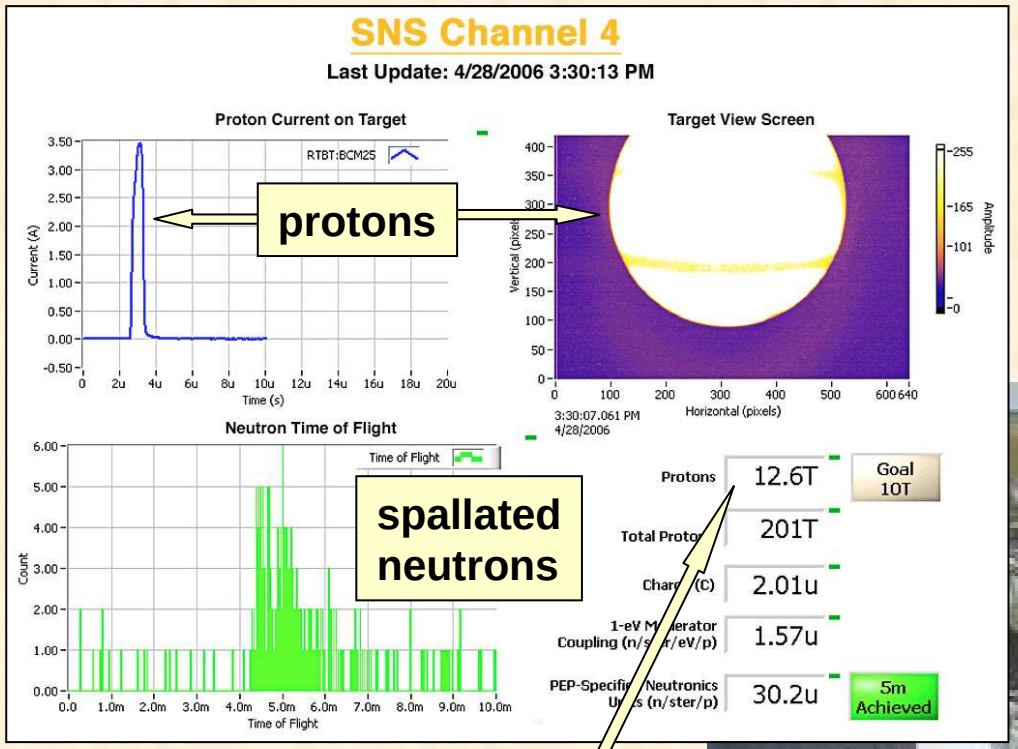
Anxious Management Team

2:04 pm - First Beam on Target

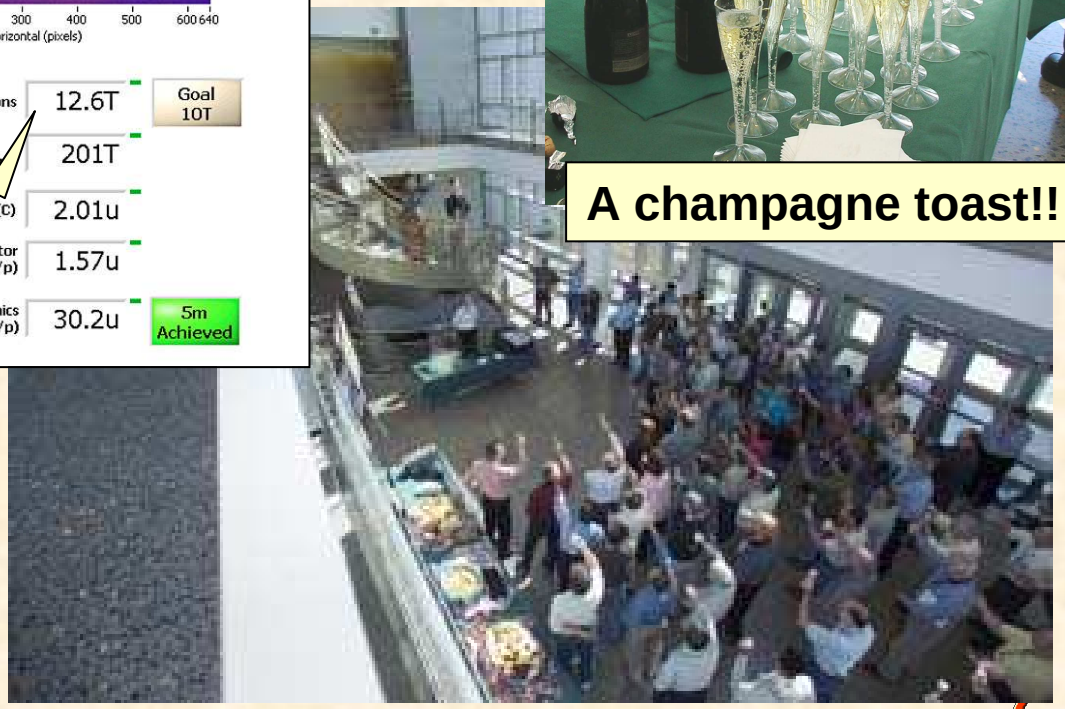


Relief and general applause

3:30pm – "CD4" intensity reached

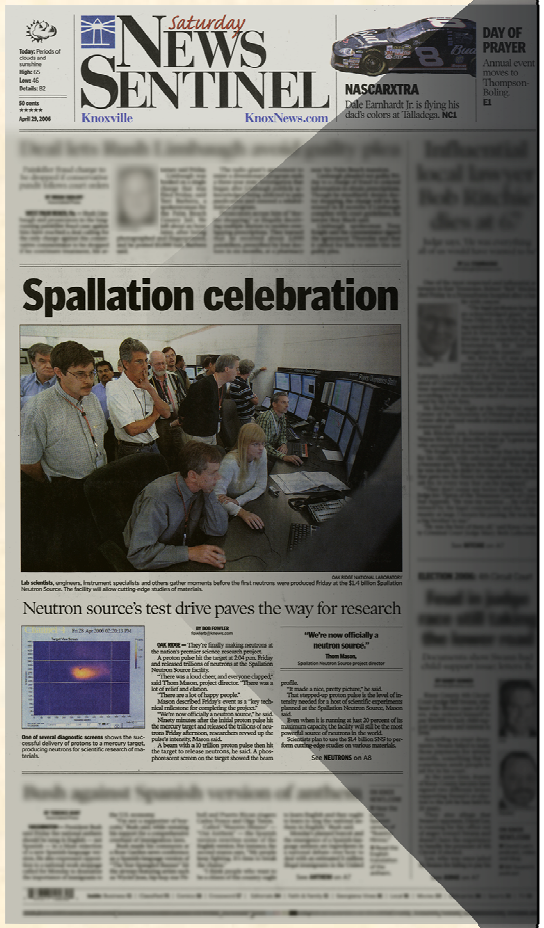


A champagne toast!!



1.26x10^{13}ppp (later reached 1.75x10^{13}ppp)

Front Page News...



Saturday
NEWS SENTINEL
Knoxville
KnoxNews.com

NASCARXTRA
Dale Earnhardt Jr. is flying his dad's colors at Talladega. NC1

DAY OF PRAYER
Annual event moves to Thompson-Boling. E1

Spallation celebration

Lab scientists, engineers, instrument specialists and others gather moments before the first neutrons were produced Friday at the $1.4 billion Spallation Neutron Source. The facility will allow cutting-edge studies of materials.

Neutron source's test drive paves the way for research

One of several diagnostic screens shows the successful delivery of protons to a mercury target, producing neutrons for scientific research of materials.

BY BOB FOWLER
fowlerb@knews.com

OAK RIDGE — They're finally making neutrons at the nation's premier science research project.

A proton pulse hit the target at 2:04 p.m. Friday and released trillions of neutrons at the Spallation Neutron Source facility.

"There was a loud cheer, and everyone clapped," said Thom Mason, project director. "There was a lot of relief and elation.

"There are a lot of happy people."

Mason described Friday's event as a "key technical milestone for completing the project."

"We're now officially a neutron source," he said.

Ninety minutes after the initial proton pulse hit the mercury target and released the trillions of neutrons Friday afternoon, researchers revved up the pulse's intensity, Mason said.

A beam with a 10 trillion proton pulse then hit the target to release neutrons, he said. A phosphorescent screen on the target showed the beam profile.

"It made a nice, pretty picture," he said.

That stepped-up proton pulse is the level of intensity needed for a host of scientific experiments planned at the Spallation Neutron Source, Mason said.

Even when it is running at just 20 percent of its maximum capacity, the facility will still be the most powerful source of neutrons in the world.

Scientists plan to use the $1.4 billion SNS to perform cutting-edge studies on various materials.

See NEUTRONS on A8

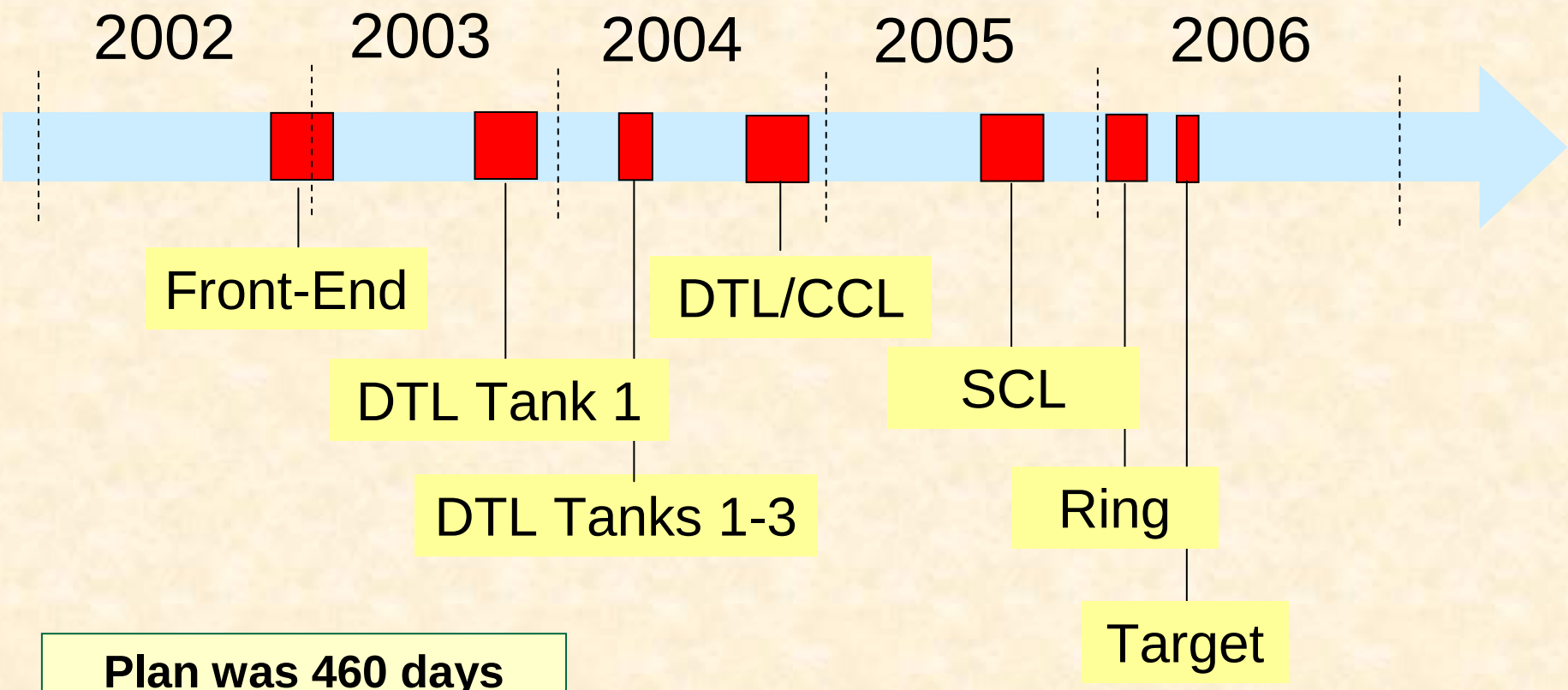
"We're now officially a neutron source."
Thom Mason,
Spallation Neutron Source project director

OAK RIDGE NATIONAL LABORATORY

06-G00735/arm

Had enough champagne, Pam??

Commissioning Timeline



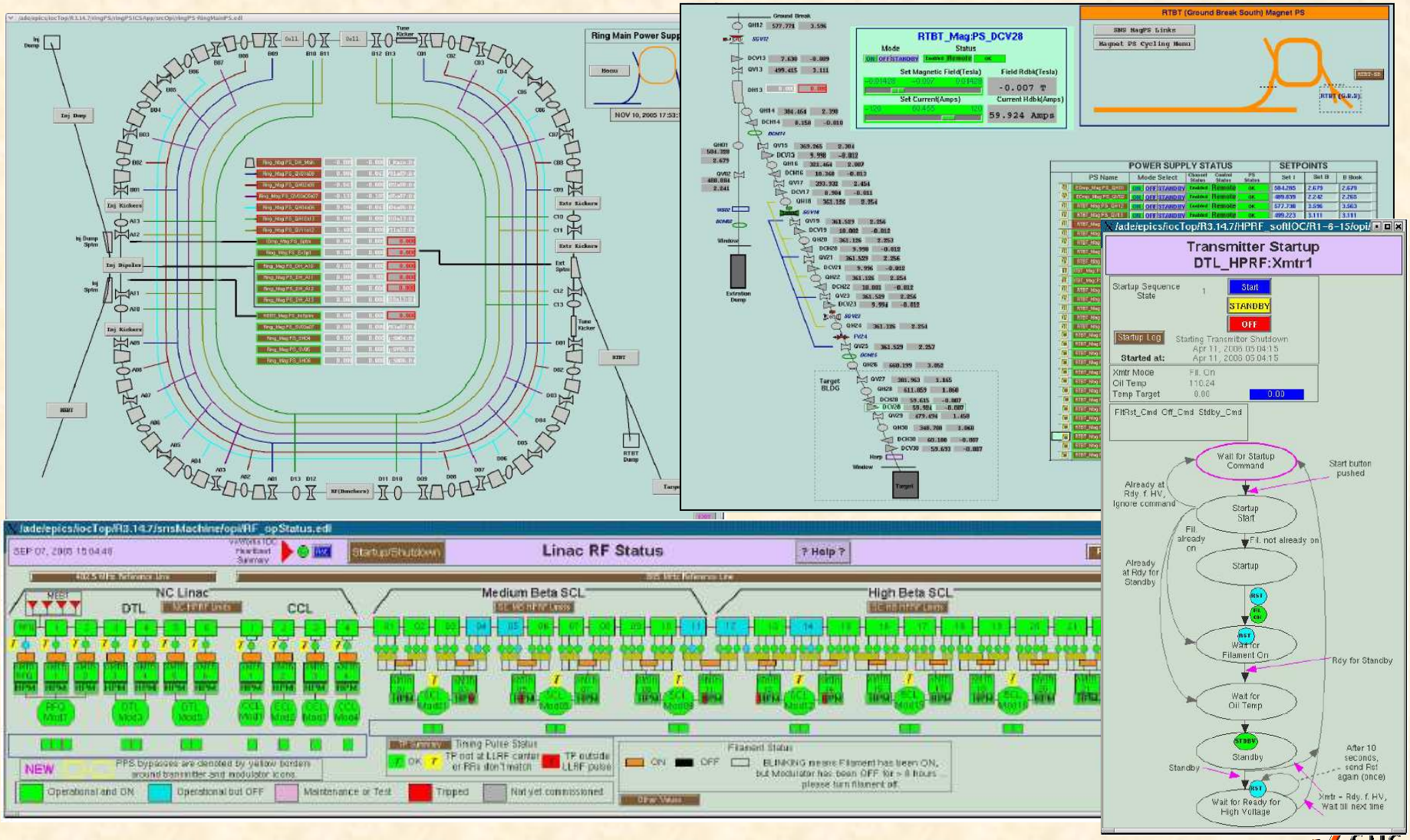
Plan was 460 days
Total was about 1 year

So now about the Control System…

SNS Controls Miscellanea

- **Target and Conventional Systems are integrated**
  - **Commercial company (Sverdrup) did EPICS and PLCs**
- **Standard system is EPICS 3.14.8.2 (a few "left behind")**
  - **VME IOCs are mostly MVME 2100s, some 5100s**
- **All PLCs (almost) are A-B ControlLogix**
  - **Most vendors complied**
- **PLC-based PPS system based on TJNAF**
  - **Includes Target and Instruments**
  - **One-way communication to EPICS**
  - **Access Control, Sweeps, ODH, Stack Monitoring, "Chipmunks"**
- **Timing system based on RHIC**
  - **Line Synch module for chopper issue**
  - **Diamond System being assembled for laser wires**
  - **NADs use same timing**

Control System has >1000 operating and engineering screens using EDM



Final Configuration includes 168 VME/VXI-based IOCs…

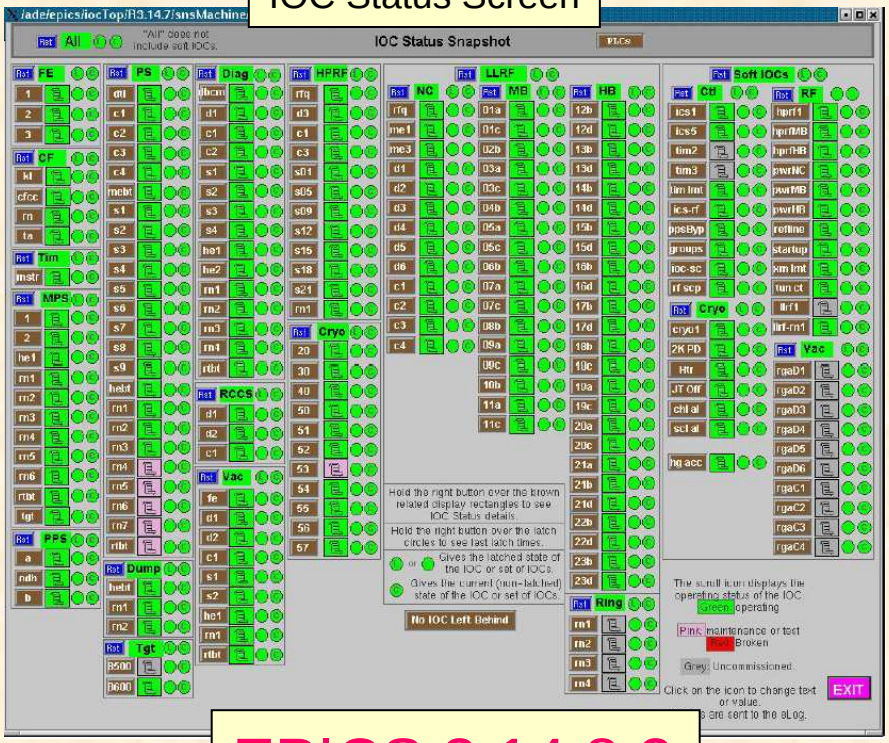
VME/VXI VxWorks-based IOCs – Accelerator Domain								
	Vacuum	RCCS	Pwr Supps	HPRF	LLRF	Diagnostics*	Misc**	**Total**
					(VXI)			
FE	1						4	5
MEBT			1		2			3
RFQ				1	1			
DTL	2	2	1	1	4	3		13
CCL	1	1	4	2	4	2		14
SCL	3		9	7	42	4	1	66
HEBT	1		1			2	2	6
Ring	1		7	1	5	4	8	26
RTBT	1		1			2	1	5
ICS							6	
								146
VME/VXI VxWorks-based IOCs – Other Domains								
Cryo							12	
Target							3	
CF							4	
PPS							3	
							22	**22**
Totals	10	3	24	12	58	17	44	**168**

- **1GB Fiber Backbone**
  - Tubes installed for future addition of "blown" fiber
- **Switch Hardware**
  - 2 "Core" Switches
  - 17 mid-level switches
  - 108 "edge" switches

… + 46 Linux-based “Soft” IOCs, + 248 Windows-based “Network Attached Devices” (NADs) for a total of 462 IOCs

Windows-based Diagnostics IOCs (“NADs”)							
	BPM	BCM	WS	LW	FBLM	Misc	Total
Linac	60	10	20	9	0	12	111
HEBT	35	5	6	0	2	0	48
Ring	45	2	1	0	8	1	57
RTBT	18	5	5	0	2	2	32
							248
Linux-based “Soft” IOCs							46
VME/VXI VxWorks-based IOCs (from last page)							168
							462

IOC Status Screen



Also >100 PLCs

EPICS 3.14.8.2

… and 39 “client servers,” and 33 OPIs (1 – 6 screens)

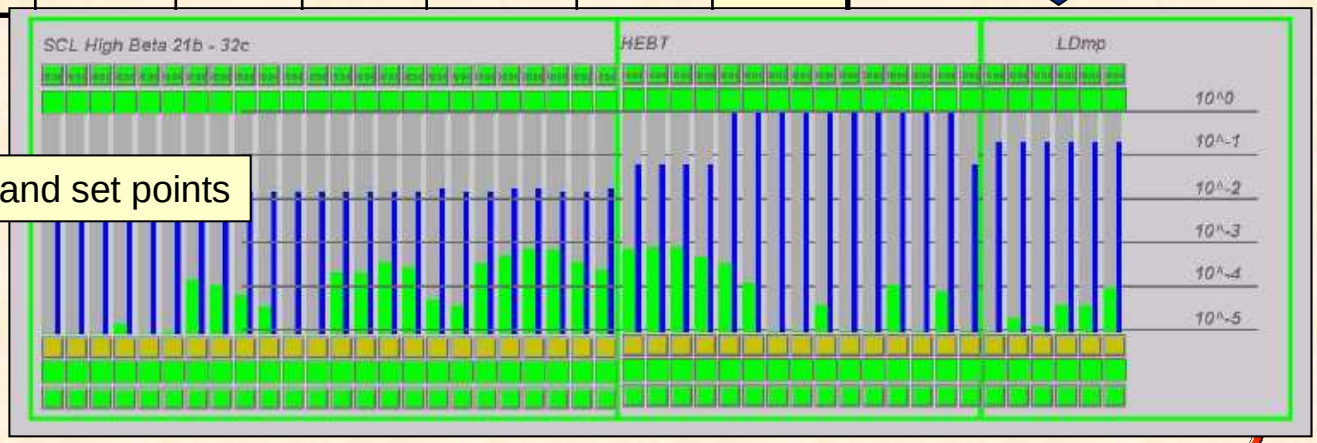
Domain	Admin	ACCL	Cryo	CF	Tgt	PPS	Total
Servers							
Domain Servers		2	1	1	2	2	8
Physics Servers		4					4
Archive Servers	3		1			1	5
Soft IOC Servers		5	1				6
Administration*	10						10
Diagnostics Servers**		6					6
							39
Consoles (OPIs)							
Console OPIs		12	5	3	6		26
“COWs”		14			3		17
							33
Input/Output Controllers (IOCs)							
IOCs (VxWorks)		146	12	4	3	3	168
“Soft” IOCs (Linux)		39	7				46
“NADs” (Windows)		248					248
							462

* DHCP/DNS (2), Network Monitoring (2), One-time password login (1), Backup (1), Relational DB (1), Remote Data Access (1)
**Windows-based

Final MPS Configuration has >900 inputs (Corrector Magnets not yet included)

	MEBT	CCL	LDmp	IDmp	Ring	EDmp	Tgt	
Chassis	**7**	**21**	**28**	**7**	**30**	**6**	**6**	**105**
PS	**11**	**15**	**52**	**31**	**143**	**32**	**25**	**309**
RF	**11**	**26**	**98**		**8**			**143**
BLM		**62**	**120**	**39**	**69**	**16**	**24**	**330**
Diag	**5**	**33**	**2**	**7**	**2**	**2**	**4**	**55**
Other	**27**	**16**	**21**	**5**	**4**	**10**	**3**	**86**
TOTAL Inputs	**54**	**152**	**293**	**82**	**226**	**60**	**56**	**923**

BLM Readings and set points

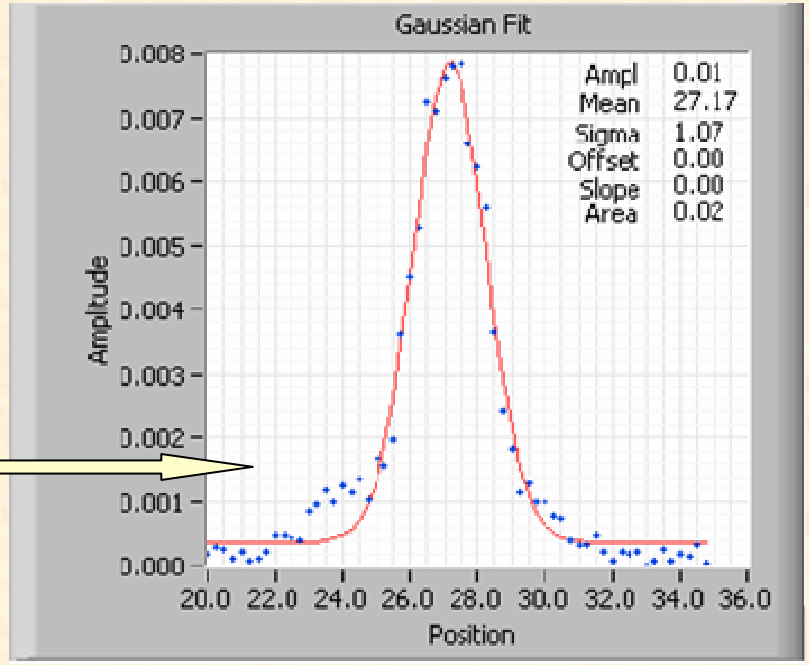


So how many "Channels" is this?

- It is difficult even to define a channel
  - Estimates were of "signals," associated with a wire or ADC
  - But what of waveforms, Smart devices, "soft" channels?
  - Whatever it is – it's hard to count
- EPICS sites usually count Database records ("PVs")
  - Easy to count, and it is at least a measure of complexity
- SNS has ~395,000 PVs, including 22,000 in NADS
  - Counted using the IRMIS "crawler" and Database query
  - Ned says this makes SNS the largest EPICS installation
- Rule-of-thumb: One "channel" needs ~5 EPICS PVs
  - That gives an estimate of 80,000 channels
  - Corroboration: 75,000 PVs are being archived
  - Post "cold linac" PCR estimate was 60,000

Complete Beam Diagnostics Suite and Commissioning Applications (XAL) were key

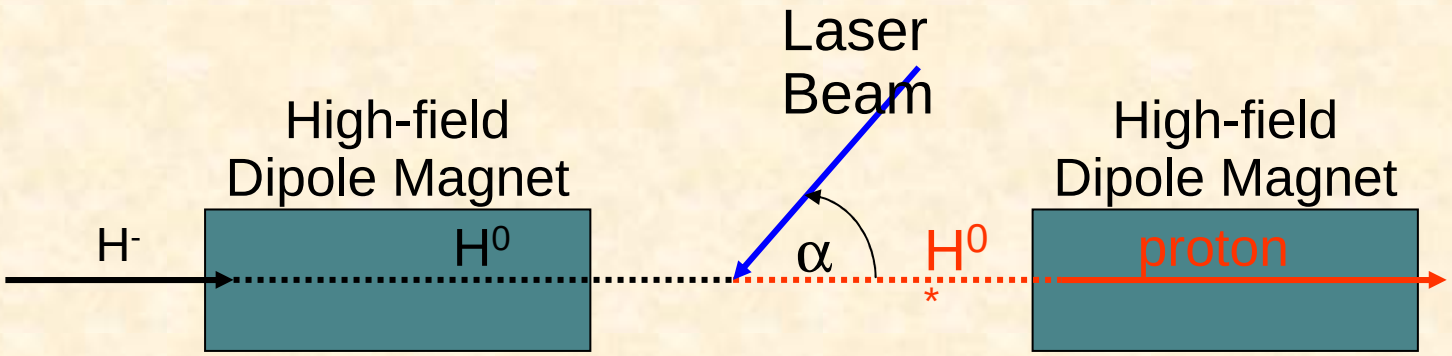
- Very large installation and testing effort completed by joint Physics/Controls Team
  - 330 BLMs
  - 158 BPMs
  - 32 Wire Scanners
  - 22 BCMs
  - 12 Fast BLMs
  - 9 “Laser Wire” Scanners
  - 15 Miscellaneous
- Labview – EPICS interface



- “XAL” Model-based Applications from the Physics Team were ready for each run
  - eg Auto-retune after loss of cavity (or cavities)

Two final SNS boasts (not Controls)

- **Upgrade to 2MW approved and R&D funded before CD-4.**
- **Laser stripping proof-of-principal demonstrated**
  - **50% efficiency demonstrated in 1 hour run (1ns pulse)**



Step 1: Lorentz Stripping

$H^- \rightarrow H^0 + e^-$

Step 2: Laser Excitation

$H^0 (n=1) + \gamma \rightarrow H^{0*} (n=3)$

Step 3: Lorentz Stripping

$H^{0*} \rightarrow p + e^-$

Issues

- **EMI Noise is a constant battle, but…**
  - **We are beating it down case-by-case**
  - **Noise is no longer the principle cause of nuisance trips**
  - **Latest (and biggest) problem is from Extraction kickers**
- **Alarm Handler work just getting started**
  - **Have made do with secondary effects, summary PVs**
- **Archive Data Management approach**
  - **6GB/day, 4.2 TB total needs management philosophy**
  - **200GB in first ten days after CD4 day (April 28)!!!**
    - **Bad News – pretty stupid archiving**
    - **Good News – system handled that rate**

Preparations Paid Off in Successful, Rapid Beam Commissioning

- Central to successful commissioning was the availability of the beam diagnostics systems on day one
  - Diagnostics systems (Beam current monitors, beam loss monitors, beam position monitors, video foil monitors) were commissioned very rapidly, providing useful information almost immediately
  - This was the result of a series of "dry-run" tests for diagnostic systems
- Excellent alignment of components eased initial tuneup
- Thorough magnet measurement program allowed "dialing-in" currents and immediately transporting beam.
- Polarity checks guaranteed straightforward beam transport
- Full integrated tests of all subsystems (DC magnets, RF, pulsed magnets, etc.) through the control system prior to beam commissioning allowed the commissioning team to focus on the beam

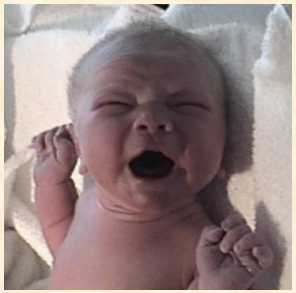
What I told the DOE CD-4 Review

- Control System completed at >$1M under budget
- Many things made success possible
  - Excellent Collaboration from our Partners – THANKS!!!
  - Making Controls a Level 2 WBS (DOE CDR suggestion)
  - Standardization
    - PLCs, IOCs, CVS, Racks, Names, Screen Colors, etc
  - Most important was the selection of EPICS!!
    - (See also Diamond, Antipodean Light Source)
- Not everything was perfect – for lessons learned see Project Completion Report
- Bottom Line: The Controls Group has had a very productive five years…

Controls Group Babies
2000 - 2006

Corinne Marie Purcell

Abigail Grace Armstrong



Samuel Cole Williams

Malia Cheyenne Williams

Jacob Thorn Stigal

Skylar Reese Williams

Isabella Denise Moss

Anna Irma Rosa Kasemir

Courtni MichelleTang